

Department of Science and Art.

GEOLOGICAL SURVEY OF THE
UNITED KINGDOM.

MUSEUM OF PRACTICAL GEOLOGY,

AND

GOVERNMENT SCHOOL OF MINES.

(11th Session. 1861-62.)



LONDON:

PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY,
FOR HER MAJESTY'S STATIONERY OFFICE.

1861.

3051.

Session 1861-62.

ARRANGEMENT OF THE LECTURES.

Hour.	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
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FIRST TERM.—October, November, December, January, and part of February.

10 to 11	Chemistry.	Chemistry.	Chemistry.	Chemistry.	Chemistry.	Examination Day.
11 to 12						
12 to 1	Metallurgy.	Metallurgy.	Metallurgy.			
1½ to 2½	Mineralogy.	Mineralogy.		Mineralogy.	Mineralogy.	
2 to 3	Natural History.	Natural History.	Natural History.			
3½ to 4½	Mining.	Mining.		Mining.	Mining.	

SECOND TERM.—Part of February, March, April, May, and June.

10 to 11						Examination Day.
11 to 12						
12 to 1	Applied Mechanics.	Applied Mechanics.	Applied Mechanics.	Applied Mechanics.	Applied Mechanics.	
1 to 2	Geology.	Geology.	Geology.	Geology.		
2 to 3						
3 to 4	Physics.	Physics.	Physics.	Physics.	Physics.	

50	Lectures on Inorganic Chemistry	} by A. W. HOFMANN, LL.D., F.R.S.	{ commencing	7th October 1861.
30	Organic Chemistry			5th January 1862.
50	Natural History	T. H. HUXLEY, F.R.S.		7th October 1861.
50	Metallurgy	J. PERCY, M.D., F.R.S.		7th " "
60	Mining	} W. W. SMYTH, M.A., F.R.S.	{	11th November "
40	Mineralogy			" " "
30	Geology	A. C. RAMSAY, F.R.S.		10th February 1862.
30	Applied Mechanics	R. WILLIS, M.A., F.R.S.		10th " "
40	Physics	J. TYNDALL, F.R.S.		5th May "

The CHEMICAL AND METALLURGICAL LABORATORIES will be opened for the Students on Monday the 7th of October 1861.

TRENHAM REEKS, Registrar.

Department of Science and Art.

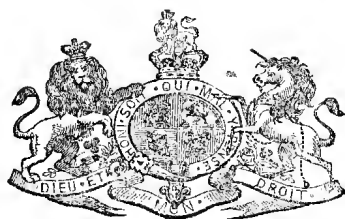
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MUSEUM OF VICTORIA



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* A table showing the number of lectures in each course, the time of its commencement, and of their delivery, will be found arranged on the inside of the front cover.



INTRODUCTION.

THE building in which the collections illustrative of the geological structure and of the mineral produce of the British islands and their dependencies, constituting the Museum of Practical Geology, are exhibited to the public, is, in addition, the seat of the Government School of Mines, and contains the central office of the Geological Survey of the United Kingdom, out of which both the Museum and the School have arisen.

In the year 1851 numerous memorials, praying for the establishment of a mining school, were addressed to the Government by the leading representatives of the mining interest of Great Britain. The memorialists urged that, though the value of the annual mineral produce of this country amounted to 28,000,000*l.*, equalling four-ninths of the total amount produced by the whole of Europe, and far exceeding that yielded by any other state, the miners and metallurgists of the United Kingdom were unable to obtain that instruction in the theory and the practice of their calling, which had long been carefully provided for their foreign competitors in the mining colleges of France, Belgium, Prussia, Saxony, Austria, Spain, and Sweden, and the effect of which, in all cases, had been a marked increase in the economy, efficiency, and safety of mining operations.

Guided by those principles of policy which had led successive administrations to establish or to support schools of art and design, for the advantage of other great manufacturing interests, the Government acceded to the request of the memorialists; the immediate realization of whose wishes was doubtless much facilitated by the circumstance that the complete nucleus of a mining school already existed in the officers, the laboratories, and the mineral and fossil collections, of the Geological Survey of the United Kingdom.

This Survey, commenced single-handed by the late Sir Henry De la Beche, in the year 1834, had undergone a slow and gradual expansion, and as the value and the necessary magnitude of its operations became more obvious, had met with more and more

support and encouragement from the State, until, in the year 1851, its working staff contained not only practical geologists and field surveyors, but a naturalist, a mining surveyor, a mineralogist, a metallurgist, and a chemist; and the extensive fossil and other collections, which were not only the fruit of the labours of the survey, but the justification of its maps, were lodged in the new and spacious museum in Jermyn Street, which had been expressly built for their display and for the purposes of the Survey, by the Government of Sir Robert Peel.

In order, therefore, to establish a school of mines, little more was necessary than that the Government should formally authorize a certain number of the officers of the Survey to teach those sciences with which it was their official duty to be acquainted; and, in fact, when the Government School of Mines was instituted in 1851, all its professors, with a single exception, were officers of the Survey and Museum, and the students were taught in the theatres and laboratories, and by means of the collections which appertained to the pre-existing establishment.

The principal object of the Institution which had thus naturally grown out of, or engrafted itself upon, the Geological Survey of the United Kingdom, has always been and is, to discipline the students of the school thoroughly in the principles of those sciences upon which the operations of the miner and metallurgist depend. Of course, nothing but experience in the mine and in the laboratory can confer the skill and tact requisite for the practical conduct of those operations; but, on the other hand, it is only by an acquaintance with scientific principles that the beginner can profit by that experience and improve upon the processes of his predecessors.

But while it has been the chief aim of the Government School of Mines to become to Britain what the Bergakademie of Freiberg and the École des Mines of Paris, are to Germany and to France, the minister by whose instructions the British equivalent of these well known foreign institutions was founded, expressly stipulated that the professors should deliver annually, at a nominal admission fee, a course of Lectures to Working Men. It appears to have been considered right that an institution subsidised by the nation should contribute to a certain extent to the great national object of educating those who are prevented by circumstances from educating themselves. These lectures were commenced in 1851, and the attendance upon them was so large, and the interest taken in the subjects discussed by the classes to

whom they were addressed was so great, that, in the following year the officers of the School of Mines voluntarily determined to increase their labours in this direction, each professor engaging to give a course of six lectures in alternate years—and thus providing the working men with an average of twenty-six, instead of six, lectures in each year.

The steady and complete success of these voluntary courses, which have now been continued over a period of ten years, has led the Professors of Chemistry, Physics, Natural History, and Geology, to extend this kind of instruction to a larger body of the people, without, however, in any way interfering with the working men's lectures. In the course of the past session (1860-61), they delivered four courses of Evening Lectures on the principles of Natural Philosophy, Chemistry, Natural History, and Geology, addressing themselves especially to persons who are unable to obtain instruction in the elements of science through those channels which are open to the possessors of wealth and leisure. These Evening Lectures were so well attended that similar courses will be given during the present session.*

While the periodical issue of the geological maps, the monographs, and the decades, and the extent, completeness, and orderly arrangement of the Museum, sufficiently testify to the past and present activity of the officers of the Survey—the Director-General would point to the important public positions now held by many former students of the School of Mines,† as satisfactory evidence of its success, during the short period of its existence: and he also appeals to the fact, that Monday after Monday, during the sessions of ten successive years, audiences of working men have filled the theatre, to prove that the professors of the institution have interpreted their constitutive instructions in no niggardly or unwilling spirit.

The Director-General and his colleagues earnestly hope that their further efforts in the same course may meet with the appreciation and support of the classes for whose benefit they are made; and that the Government School of Mines may ultimately attain the utmost amount of usefulness, as a means of diffusing sound elementary instruction in science among the masses, that may be consistent with its full efficiency as an aid to the development of one of the greatest interests of a commercial country.

* See p. 32.

† See p. 14.

The Geological Survey of the United Kingdom.

The Geological Survey is conducted by the following officers :—

Director-General.—Sir R. I. Murchison, D.C.L., LL.D., F.R.S.

Local Directors.—A. C. Ramsay, F.R.S. (*Great Britain*);

J. Beete Jukes, F.R.S. (*Ireland*).

Senior Geologists.—H. W. Bristow, W. T. Aveline, H. H.

Howell, and Edward Hull, B.A. (*Great Britain*); Geo.

V. Du Noyer and William H. Baily (*Ireland*).

Assistant Geologists.—F. Drew, A. Geikie, E. Best, W.

Whitaker, B.A., T. R. Polwhele, M.A., C. Le Neve Foster,

John Young, M.D., Thos. McK. Hughes, M.A., Alexander

Green, M.A. (*Great Britain*); F. Foot, G. H. Kinahan,

J. O'Kelly, A. B. Wynne, and J. Kelly (*Ireland*).

Naturalist.—T. H. Huxley, F.R.S.

Assistant Naturalist.—R. Etheridge.

Palaontologist.—J. W. Salter.

Assistant Palaontologist.—George Sharman.

The final object of the Geological Survey is to arrange, in a form easily accessible to the public, a complete body of information respecting the true geological structure of the British islands and the disposition and the extent of their mineral wealth; such information, as it is obtained, has been and will continue to be, incorporated in the publications of the Survey, which consist of :—

1. *Geological Maps* based upon those prepared by the Ordnance Survey, and exhibiting the distribution of the strata.

2. *Geological Sections* exhibiting the order and mode of superposition of those strata, along particular lines of the districts surveyed.

3. *Explanatory Descriptions* accompanying and elucidating the maps and sections.

4. *Memoirs*, which comprise :

a. Detailed geological, mineralogical, and metallurgical essays upon questions of importance connected with the structure or the mineral products of the country.

b. Illustrated monographs and decades descriptive of new, or otherwise important, fossil remains which have come under the notice of the Survey.

c. Mineral statistics or returns of the produce of the mines of the United Kingdom.

d. Catalogues of the contents of the Museum.

The maps, and other publications of the Survey are to be obtained of—

Messrs. Longman and Co., Paternoster Row, London.

Messrs. Letts and Son, Royal Exchange, - „

Mr. Stanford, Charing Cross, - - - „

Messrs. W. and A. Johnston, St. Andrew's Square, Edinburgh.

Messrs. G. Philip and Son, South Castle Street, Liverpool.

Messrs. Napper and Wright, New Street, Birmingham.

Mr. Lavers, Bristol.

Mr. E. Slater, St. Ann's Square, Manchester.

Mr. A. Lea, Westgate Street, Gloucester.

The Museum of Practical Geology.

The contents of the Museum may be classed under the following heads :—

1. Fossil organic remains arranged in their order of superposition or age, so as to illustrate the geological maps and sections.

2. The geological maps of England and Wales united in one general map to exhibit the progress of the survey, with a few illustrative sections, the remainder of these documents being kept in the map office.

3. Specimens of British sedimentary rocks arranged partly in order of superposition and partly with reference to their mode of accumulation and their subsequent modifications ; also specimens of igneous rocks arranged lithologically.

4. Specimens of building stones and of mineral substances used in the construction of public works and buildings, and of those employed for ornamental and decorative purposes.

5. Specimens illustrative of the ores of the useful metals, of their mode of occurrence, and of the methods used in preparing them for smelting.

6. The various arts, such as pottery, enamelling, glass-making, founding, &c., connected with the mineral and metallurgical resources of the country, as illustrated by specimens showing varieties or peculiarities of manufacture.

7. Models of mines, mining tools, and working models of mining machinery, with a view of exhibiting the various modes of mining in different districts.

The organization of the Museum is based upon the following instructions contained in the "Report of Committees of Inquiry into Public Offices," 1854.

"With regard to the important subject of the curatorship of the Museum, we find that the professors are generally of opinion that no single person could be found who would be competent to undertake the detailed arrangement of the whole, and that each professor ought to have the special care of that part which relates to his own department. We therefore consider that the registrar of the College should be charged with such general superintendence as he can give to the whole collection, and that the more particular care and arrangement of the several departments should be left to the professors, subject to the supervision of the director."

In accordance with the above directions, the several departments of the Museum are placed under the following officers:—

The collection of Fossil Specimens.—PROFESSOR HUXLEY.

<i>Assistants</i>	-	-	{	ROBT. ETHERIDGE.
			{	GEORGE SHARMAN.

The collection of Rock Specimens.—PROFESSOR RAMSAY.

<i>The collection of Metallurgical</i>	}	DR. PERCY.
<i>Specimens</i>		

<i>The Collection of Mineralogical</i>	}	WARINGTON W. SMYTH.
<i>Specimens</i>		

<i>General Curator</i>	-	-	-	TRENHAM REEKS.
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The Mining Record Office.

Considerable loss of capital has frequently resulted from attempts to mine in localities, where a little knowledge of what had been previously done would have shown there was small prospect of success. Through ignorance of the existence or exact extent of old and deserted mine workings, great danger to the miner is not uncommonly incurred, and human life has been frequently sacrificed. The preservation of Mining Records has for one of its objects the prevention of such loss of life and of property.

A large collection of plans and sections of mines, and important statistical details, are deposited in this Office, under the superintendence of the Keeper of the Mining Records. They are made available for the instruction of students, and may be consulted

by those who are interested in the mineral productions of the United Kingdom.

Another and perhaps the most important object of this office is the collection and annual publication of the "Mineral Statistics of the United Kingdom."

Keeper of Mining Records.—ROBERT HUNT, F.R.S.

Assistants { RICHARD MEADE.
J. B. JORDAN.

The Library.

The library contains a carefully selected collection of works bearing upon the questions with which the officers of the Institution have to deal, or which are necessary for the students of the school, including complete sets of the most important foreign and English scientific periodicals. Although the library could not be conveniently made a public one, every facility is given to persons who wish to use it for scientific purposes.

Librarian.—TRENHAM REEKS.

Assistant Librarian and Clerk.—THOS. NEWTON.

The Government School of Mines.

The Government School of Mines is conducted by the following officers:—

Sir RODERICK IMPEY MURCHISON, D.C.L., LL.D., F.R.S., &c.—*Director.*

A. W. HOFMANN, L.L.D., F.R.S.—Lecturer on *Chemistry*.

T. H. HUXLEY, F.R.S.—Lecturer on *General Natural History*.

JOHN TYNDALL, F.R.S.—Lecturer on *Physics*.

ROBERT WILLIS, M.A., F.R.S.—Lecturer on *Applied Mechanics*.

JOHN PERCY, M.D., F.R.S.—Lecturer on *Metallurgy*.

A. C. RAMSAY, F.R.S.—Lecturer on *Geology*.

WARINGTON W. SMYTH, M.A., F.R.S.—Lecturer on $\left\{ \begin{array}{l} \textit{Mining.} \\ \textit{Mineralogy.} \end{array} \right.$

TRENIAM REEKS.—*Registrar.*

Regulations of Admission.

The public will be admitted to the lectures on payment of *three pounds* for each course of forty or more lectures, and *two pounds* for the course of thirty and under forty lectures. *Certificates of Attendance* will be granted to all who attend the lectures, but students desirous of obtaining *Certificates of Proficiency* will be required to pass the examinations and pay an additional fee of *one pound* per course.

Persons following the course of study prescribed hereafter (page 16), and passing the final examinations in the first class, are entitled to receive an official certificate with the title of ASSOCIATE OF THE GOVERNMENT SCHOOL OF MINES.

ASSOCIATES OF THE GOVERNMENT SCHOOL OF MINES will be entitled for life to have access to the library and to all the courses of lectures.

The fee for students desirous of becoming ASSOCIATES and of competing for the Duke of Cornwall's Exhibition is *thirty pounds* in one sum on entrance, or two annual payments of *twenty pounds* each.

The chemical and metallurgical laboratories are open to all students, whether attending the lectures or not. The fees (which are not included in the above) will be found at pages 22 and 30.

PUPIL TEACHERS from Training Schools, recommended by the Committee of Privy Council on Education, or producing certificates satisfactory to the Director, may attend the day Lectures gratuitously, provided that they be examined in at least one subject, paying a fee for such examination of *one pound* per course.

PERPETUAL TICKETS are issued, which entitle the holder to attend all present and future Courses of Lectures, upon payment of *forty pounds*.

Officers of the Army and Navy, Her Majesty's Consular and Diplomatic Officers, and acting Mine-Agents and Managers of Mines are admitted to the Lectures at half the above charges.

By order of the Secretary of State for India, the certificate of the Professor of Metallurgy is received for appointments in the Mints of India.

The Chemical and Metallurgical Laboratories will be opened for Students on Monday the 7th day of October 1861.

Further information may be obtained by application to Mr. TRENHAM REEKS, Registrar, Museum of Practical Geology, Jermyn-street, London. S.W.

Exhibitions.

There are various Exhibitions attached to the School, some of them being general—open to all pupils; the others being special in their nature, or connected with particular Provincial Schools.

I. *The Duke of Cornwall's Exhibition.*

H.R.H. the Prince of Wales, as Duke of Cornwall, has granted two Exhibitions of thirty pounds each. One becomes vacant every year, and will be competed for by those Students only, who have past through the Studies of the first two years of the curriculum required for Associates. It is held for two years by the successful competitor.

II. *Government Prizes.*

Two prizes of five and two pounds respectively are given to the Students who occupy the first and second places in the final examinations of each course of lectures.

III. *Queen's Gold Medallists Exhibitions.*

The Council of the Government School of Mines offers a Free Scholarship, conferring the privilege of attending all Lectures and Examinations without payment of fees, to any person who obtains a Queen's Gold Medal at the Annual May Examination of Science Classes of the Department of Science and Art.

IV.—*Provincial Exhibitions.*

The Council of the School provides free Scholarships for certain Provincial Schools.

V.—*The Edward Forbes Medal.*

The Trustees appointed by the Committee of the Edward Forbes Memorial Fund have presented to the Institution a bronze medal and a prize of books, to be competed for annually, and to be awarded to the Student who shall be found to possess the best knowledge of Natural History and Paleontology.

VI.—*The De la Beche Medal.*

The Council awards annually to the Student who shall have exhibited the greatest proficiency in mining and any other

branch of science taught in the school, a bronze medal and prize of books, established in memory of the late director, Sir Henry De la Beche.

VII.—*The Director's Prize.*

A prize of the value of *Twenty-five* pounds, the gift of the Director, Sir Roderiek Murchison, will be awarded annually to the Student who stands highest in the Geological examination and in any one of the other subjects taught in the School of Mines.

List of Students to whom Prizes have been
awarded.

The Duke of Cornwall's Exhibition.

Session 1851-2	-	-	-	- Henry Francis Blanford.*
„ „ (for one year)	-	-	-	- Robert Hunt.†
„ 1852-3	-	-	-	- William Thomas Blanford.‡
„ 1853-4	-	-	-	- Frederie Drew.§
„ 1854-5	-	-	-	- Charles Gould.
„ 1855-6	-	-	-	- John Morland.
„ 1856-7	-	-	-	- William Weston.
„ 1857-8	-	-	-	- Clement Le Neve Foster.§
„ 1858-9	-	-	-	- Thomas William Danby.
„ 1859-60	-	-	-	- William Haekney.
„ 1860-61	-	-	-	- Frederick Charles Bishopp.

Government Prizes.

1855.	1st Year's Student,	25 <i>l.</i> to	-	-	Ambrose Tween.*
„	2d Year's Students,	15 <i>l.</i> to	-	-	{ Frederie Drew. George P. WALL.¶
1856.	1st Year's Students,	25 <i>l.</i> to	-	-	{ Edward Matthey. Mark Bullen.
„	2d Year's Students,	15 <i>l.</i> to	-	-	{ Charles Gould. Ambrose Tween.*

* Of the Geological Survey of India.

† Mint, Sydney.

‡ Of the Geological Survey of India.

“ ” Great Britain.

§. Superintendent of the Geological Survey of Tasmania.

Directed the Geological Survey of Trinidad.

1857. 2d Year's Students, 15 <i>l.</i> to -	- { Richard Thornton. John Morland.
1858. 1st Year's Student, 15 <i>l.</i> to "	- T. W. Danby.
" 2d Year's Student, 25 <i>l.</i> to "	- Ch. S. Wood.
" 2d Year's Student, 15 <i>l.</i> to "	- William Weston.
1859. 1st Year's Students, 15 <i>l.</i> to -	- { William Hackney. Walter Child.
" 1st Year's Students, 15 <i>l.</i> to "	- { F. C. Bishopp. Clement Wilkinson.
" 2d Year's Student, 25 <i>l.</i> to "	- Walter Child.
1860. 1st Year's Student, 15 <i>l.</i> to "	- S. B. Tawney.
" 2d Year's Student, 25 <i>l.</i> to "	- Clement Wilkinson.

The Edward Forbes Medal and Prize of Books.

Awarded in 1855 to Frederic Drew.
" 1856 to Charles Gould.
" 1857 to John Morland.
" 1858 <i>No Candidate.</i>
" 1859 to Clement Le Neve Foster.
" 1860 to Thomas William Danby.
" 1861 to Walter Child.

The De la Beehe Medal and Prize of Books.

Awarded in 1857 to Richard Thornton.
" 1858 to William Weston.
" 1859 to Ch. S. Wood.
" 1860 to Thomas William Danby.
" 1861 to William Hackney.

Plan of Instruction.

The mode of instruction is by systematic courses of Lectures, by written and oral Examinations, by practical teaching in the Laboratories and Drawing Office, and also, under certain conditions, by Field Excursions.

Persons who desire to become ASSOCIATES OF THE GOVERNMENT SCHOOL OF MINES are required to pass through the following course of study:—

1st YEAR.

FOR ALL DIVISIONS.

1st TERM.

*Oct., Nov., Dec., Jan., part
of Feb.*

Inorganic Chemistry, with
practice in laboratory.
(Mechanical Drawing.)

2nd TERM.

*Part of Feb., Mar., April,
May, June.*

Physics.
Laboratory Practice.

2nd YEAR.

FOR ALL DIVISIONS.

1st TERM.

Mineralogy.
(Mechanical Drawing—*cont.*)

2nd TERM.

Geology.

3rd YEAR.

MINING DIVISION.

1st TERM.

Mining.
Assaying.

2nd TERM.

Applied Mechanics.

METALLURGICAL DIVISION.

1st TERM.

Metallurgy, with practice
in laboratory.

2nd TERM.

Applied Mechanics.
Metallurgical Practice.

GEOLOGICAL DIVISION.

1st TERM.

Natural History and
Palæontology.

2nd TERM.

Palæontological Demon-
strations.

Every Candidate for Associateship must acquire a sufficient knowledge of the subjects enumerated in this table for the first and second years; but in the third year he may confine himself to the Mining, Metallurgical, or Geological Divisions, and pass his final examinations in the subjects of one of those divisions only.

The courses of instruction are distributed over three years, but those Students who possess sufficient preliminary training may, if they think fit, pass through the whole in two years, by presenting themselves, at the end of the first year, for examination in the subjects allotted to the first and second years.

Persons desirous of obtaining the distinction of Associate of the Government School of Mines, who have already acquired a knowledge of the subjects of the first two years, may proceed at once to the courses of the third year, by passing a special examination in those subjects before the Professors of the Government School of Mines, and paying the ordinary fees for such examinations.

SYLLABUSES

OF

LECTURES AND LABORATORY PRACTICE.

Chemistry.

The instruction in chemical science embraces :—

1. *A Course of Lectures on Experimental Chemistry with special reference to the applications of Chemistry in the Arts and Manufactures.*
2. *A systematic Laboratory Course for the Practice of Chemical Analysis.*

CHEMICAL LECTURES.

The course consists of 50 lectures on Mineral Chemistry and 30 lectures on Organic Chemistry.

The lectures are delivered in the Theatre of the Royal College of Chemistry, Oxford Street.

SYLLABUS OF LECTURES.

MINERAL CHEMISTRY.

Matter, simple and compound.

Chemical combination and mechanical mixture.

Classification of elementary bodies. Metallic and non-metallic bodies.

NON-METALLIC ELEMENTS.

Oxygen.—Nature of combustion. The phenomena attending combustion. Respiration. Ozone.

Hydrogen.—Water. Water as a type. Oxygenides. Hydrogenides. Uses of water in the laboratory and in the arts.

Nitrogen.—Chemical constitution of the atmosphere. Principles of eudiometry. Diffusion of gases. The oxides of nitrogen and nitric acid. Combination by multiple proportions. Ammonia. Ammonia as a type.

Chlorine, Bromine, and Iodine.—Hydrochloric acid. Aqua regia. Hydrochloric acid as a type. The hydric acids of bromine and iodine. Oxygen compounds of these elements. Theory of bleaching. Disinfection.

Fluorine and hydrofluoric acid.—Etching and engraving on glass.

Sulphur.—Oxygen compounds of sulphur. Sulphurous acid. Bleaching of wool and silk. Manufacture of sulphuric acid. Chemical applications of sulphuric acid in the laboratory and in the arts. Sulphuretted hydrogen. Its use as an analytical agent.

Phosphorus.—Manufacture of matches. Oxygen and hydrogen compounds of phosphorus. Theory of acids. Monobasic, dibasic, and tribasic acids.

Carbon.—Diamond. Graphite. Amorphous carbon. Carbonization. Different varieties of charcoal and their application for decolorization and disinfection. Carbonic oxide and carbonic acid. The hydrogen compounds of carbon. Manufacture of coal-gas. Nature of flame. Fuel. Principles of illumination. Foul air of mines; fire-damp; choke-damp. Safety lamp.

Silicium and *Boron*.—Their compounds with the elements previously enumerated. Manufacture of boracic acid.

Retrospect of laws of combination by weight and by volume, as deduced from the history of the individual elements. Equivalent numbers. Equivalent volumes. Symbolical notation. Formulæ. Nomenclature.

Chemical affinity. — Solution. Isomorphism. Dimorphism. Allotropic condition of matter.

METALS.

Characters of metals as a class. Processes of reduction. Alloys. Classification of the metals.

Principal compounds of the metals with the non-metallic elements. Theory of Salts.

Potassium.—Sources of potassium. Disintegration of rocks. Potashes. Nitre and nitrification. Gunpowder. Manufacture of chlorate of potassium.

Sodium.—Technology of common salt. Manufacture of sulphate and carbonate of sodium. Compounds of sodium with phosphoric acid. Borax. *Barium*. *Strontium*.

Calcium.—Mortars. Cements. Hardness of water. Conditions of water supply for domestic purposes. Purification of water. Manufacture of bleaching powder.

Magnesium. *Aluminium*.—Glass and pottery. Manufacture of alum. Mordants.

Manganese.—Its oxides and acids. Manganates and permanganates as disinfectants.

Iron.—Composition and properties of cast iron, wrought iron, and steel.

Chromium.—Its oxides and acids. Manufacture of chromate of potassium.

Cobalt. Nickel. Zinc.—Zinc white.

Cadmium.—Cadmium yellow.

Lead.—Manufacture of white lead. Chrome yellow.

Copper.—Electrotype process.

Mercury.—Manufacture of vermillion. *Bismuth*.

Tin.—Manufacture of mirrors.

Arsenic.—Course of examination in cases of poisoning by arsenic. *Antimony*.

Silver.—Chemical action of light: Photography. Silvering of glass. *Gold. Platinum*.

ORGANIC CHEMISTRY.

Ultimate analysis of organic bodies. Calculation of empirical formulæ. Methods of controlling empirical formulæ. Determination of the equivalents of organic acids and bases; examination of products of decomposition; determination of the vapour density of volatile bodies.

Law of substitution. Compound radicals. Homologous series.

The chemical history of the cyanogen group. Cyanogen. Hydrocyanic acid. Cyanic acid and urea. Cyanuric acid. Sulphocyanic acid. Chlorides of cyanogen. Fulminates. Manufacture of yellow and red prussiate of potassium. Applications of these compounds in dyeing. Nitroprussides. Uric acid.

Amylaceous and saccharine substances. Fermentations. Alcohol, wine, beer, bread, &c.

Homologues of alcohol. Ethers, simple and mixed. Oxidation of alcohol. Aldehyde and acetic acid and their homologues. Anhydrides, simple and mixed. Compound ethers.

Diatomic alcohols and their acids. Glycol and oxalic acid and their homologues.

Triatomic alcohols. Glycerin. Fatty and oily bodies. Saponification. Manufacture of soap and candles.

Group of aromatic compounds. Benzoic alcohol. Benzoic aldehyde (oil of bitter almonds). Benzoic acids. Homologues of the benzoic series.

Salicin. Salicylous and salicylic acids. Phenyl compounds.

Tartaric and citric acids.

Tannic and gallic acids. Manufacture of leather.

Ammonia. Ammonium and ammoniacal salts. Manufacture of ammoniacal salts from gas liquors.

Derivatives of ammonia. Amides and amidic acids.

Amines: Their formation and classification illustrated by the history of the compounds of ethylammonium, diethylammonium, triethylammonium, and tetrethylammonium. Amines of the phenyl series. Aniline and its applications. Natural alkaloids.

Analogues of the ammonia derivatives in the phosphorous, arsenic, and antimony series. Phosphines, arsines, and stibines. Phosphonium, arsonium, and stibonium compounds.

Coloring matters. Indigo and its derivatives. Principles of dyeing.

The chief constituents of the vegetal organism. Cellulose. Starch. Vegetal fibrin. Albumin, casein, and gluten, &c.

The chief constituents of the animal organism. Animal fibrin, albumin, casein, gelatin. Blood, milk, bile, urine, &c.

Decay, putrefaction. Destructive distillation.

The chemical principles of the process of nutrition and of respiration in plants and animals.

Chemical Laboratory.

The general Laboratory for instruction in chemical manipulation, in qualitative and quantitative analysis, and in the method of performing chemical researches, is under the direction of Dr. Hofmann. The ROYAL COLLEGE OF CHEMISTRY having become the property of the Government, its spacious and well-furnished Laboratories are used for the instruction of the pupils of the Government School of Mines.

There are three sessions in the collegiate year, of three months each. The Laboratory hours are from 10 a.m. to 5 p.m., with the exception of Saturdays, when the Laboratory closes at two o'clock.

The Laboratory instruction is necessarily adapted to the previous knowledge of the student, such as he may have acquired by attending the chemical lectures delivered at the Institution or elsewhere. The course commences with experimental exercises, calculated to make the pupil *practically* acquainted with the *general* properties of the simple substances, and of their most important compounds. The next subjects of his study are the *analytical* properties of bodies, *i.e.*, those properties on which their detection, their separation from one another, and their estimation depend. The knowledge thus acquired is subsequently put into practice in the performance of a series of analyses, so arranged as to lead the student, step by step, from the simpler to the more complex cases, both of *qualitative* and *quantitative* analysis. Particular attention is paid to the use of the blow-

pipe, and the various methods of testing and estimating the value of commercial and industrial products, alkalimetry, chlorimetry, and volumetrical analysis in general.

The fundamental studies in Practical Chemistry are the same for all pupils, however different the future pursuit may be to which the knowledge obtained will be applied. It is only after the most important methods of distinguishing, separating, and estimating substances have been mastered, and after sufficient practice and skill in experimenting have been acquired, that the course of each student diverges into some special line. This will of necessity vary with his abilities and his ultimate objects.

Each laboratory student works independently, there being no classes. All operations are superintended by the Professor and his Assistants. A table with drawers, cupboards, and shelves, is appropriated to every pupil. The Institution supplies gas, fuel, and reagents. The larger and more expensive instruments of the Laboratory, such as air-pumps, thermometers, barometers, condensers, &c., may be used by the students, who are held responsible for their safety. The students have to provide themselves only with the apparatus specified in the Laboratory regulations. More advanced students engaged in private researches have to supply themselves with such materials as are not included amongst the ordinary reagents of the Laboratory.

REGULATIONS OF THE LABORATORY.

I. Each student on entering deposits ten shillings, in return for which he receives the keys of his table and closet, and also a set of reagents. On delivering up the keys and the set of reagents, after the completion of the period of his study, the deposit is returned.

II. Students engaged in qualitative analysis have to supply themselves with a set of apparatus, consisting of the following articles :—

SET OF APPARATUS USED IN QUALITATIVE ANALYSIS.

Test tube stand.	Crucible tongs.
Two dozen German test tubes.	Two small iron spoons.
Two wide boiling tubes.	Black's blowpipe.
Five glass funnels.	Platinum wire and foil.
Three porcelain dishes.	Two test tube cleaners.
Two hard glass flasks.	Sol. of chloride of gold and bottle.
Three Florence flasks.	„ bichloride of platinum and bottle
Three glass stirring rods.	„ nitrate of silver „
Quarter pound glass tubing.	„ protonitrate of cobalt „
Washing bottle.	Bottle of methylated spirit.
Small gas jet (Bunsen's).	Several packets of filters.
Set of beakers.	Test papers.
Small mortar and pestle.	Sulphuretted hydrogen apparatus.
Six watch glasses.	Basket for draining test tubes.
Two files in handles.	India-rubber tubing for gas.
Small cork borers.	India-rubber tubing for connectors.
Corks.	

The reagents, gas, and fuel are furnished by the laboratory.

III. Students engaged in quantitative analysis have to supply themselves with a set of weights.

Balances, barometers, thermometers, burettes, and graduated vessels are furnished by the laboratory. All breakages are to be made good.

IV. In special scientific investigations chosen by the students themselves, the substances investigated or the materials employed for obtaining them shall be found by the students at their own expense, and also the materials employed in the preparation, purification, and analysis of such substances, when employed in large quantities or chemically pure, such as ether, absolute alcohol, carbonate, and caustic barytes, &c., &c.

Raw cheaper materials, such as carbonate of soda, acids, &c., will be supplied by the College.

V. All preparations made from materials supplied by the College become the property of the College.

VI. No experiments of a dangerous character are to be performed without the previous knowledge of the professor or his assistant.

The charge for instruction in the chemical laboratory is *twelve* pounds for three months, *nine* for two months, and *five* for one month.

Physics.

The course on Experimental Philosophy consists at present of forty lectures, which are thus divided :—

I. *Four Lectures on Magnetism.*—The natural magnet or load-stone; excitement of magnetism; magnetic polarity; magnetic induction; magnetic curves; measurement of magnetic force; applications to the phenomena of terrestrial magnetism.

II. *Six Lectures on Frictional Electricity.*—Electrical excitation; duality of the electric force; electrometers; hypothesis of electric fluids; conduction and insulation; distribution of electricity on the surfaces of conductors; action of points; lightning conductors; the condenser; the Leyden jar; the electrophorous; discharge of the Leyden battery through various media; measurement of electric force; applications to the phenomena of atmospheric electricity.

III. *Six Lectures on Voltaic Electricity.*—Discoveries of Galvani and Volta; simple Voltaic combinations; the Voltaic pile; contact and chemical theories; galvanometers; magnetic action of electric current; action of magnets and of the earth upon moveable currents; action of currents upon each other; chemical

action of current ; electro-plating, &c. ; light and heat produced by the current ; connection between heat and resistance ; induced currents ; measurement of electric currents ; laws of Ohm ; the electric telegraph.

IV. *One Lecture on Diamagnetism and the Magnetic Properties of Crystals.*

V. *Two Lectures on the Mechanical Properties of Air and Water.*—Constitution of gases ; pressure of the atmosphere ; Magdeburgh hemispheres ; experiments with the air-pump ; the common pump ; law of Mariotte ; hydrostatic bellows ; hydrostatic press ; hydraulic ram ; cohesion of water ; deviation of projectiles in air.

VI. *Four Lectures on Sound.*—Mode of generation and propagation ; velocity through various media ; echoes ; noise and music ; musical notes of strings, plates, and tubes ; longitudinal and transverse vibrations ; modes of vibration rendered visible ; cause of harmony ; the gamut ; harmonic division of strings and tubes ; resonance ; interference of sound ; singing flames.

VII. *Eight Lectures on Light.*—Velocity and intensity of light, how measured ; reflection and refraction ; action of lenses ; spherical aberration ; the eye and vision ; principle of the stereoscope ; irradiation ; composition of light ; the solar spectrum ; electric spectra ; absorption of light ; doctrine of colours ; chromatic aberration ; optical instruments ; theories of emission and undulation ; analogies with sound ; interference of light ; colours of iridescent films ; Newton's rings ; diffraction ; polarization of light, by reflection, refraction, and by its passage through crystals ; chromatic effects ; effects of heat, strain, pressure, and magnetism on transparent media.

VIII. *Eight Lectures on Heat.*—Principle and construction of thermometers ; expansion of bodies by heat ; exceptions to this law ; conduction and convection ; boiling points ; specific heat ; latent heat ; evaporation, condensation, congelation ; spheroidal state ; heat regarded as a mode of motion ; radiant heat ; modes of measurement ; the air thermometer ; the thermo-electric pile ; reflection, refraction, and polarization of heat ; diathermancy doctrine of thermal colours ; terrestrial radiation and its effects.

Natural History.

(Including Comparative Anatomy and Palæontology.)

The object of the Course of Lectures on Natural History is to convey to the Students of the School of Mines such a knowledge of the principles, and of the details, of Biological Science, as is necessary to the right understanding of the nature and import of Fossil organic remains.

The method of instruction comprises lectures, oral and written examinations upon the subjects of those lectures and demonstrations.

Lectures.—The Course of Lectures is divided into three parts, ~~the first of which is given every year, the second and third in alternate years.~~

The *first part* embraces the following subjects:—

The elementary principles of Physiology and Morphology.

The structure and development of the following animals:—A *Spongilla*, a *Cyanæa*, a freshwater Mussel, a Lobster, and an Osseous Fish, considered as types of the leading divisions of the animal kingdom. The structure of these animals is, as far as possible, demonstrated to the student, and is explained in such a manner as to familiarise him with anatomical and zoological terminology, and to furnish him with a sound and real, however narrow, basis, on which to build his further studies.

The relations of the different types of animal structure to one another.

The scale of animal life, and the zoological position of Man. Species, their nature and mutual relations. The conditions of life and their consequences—the laws of Bathymetrical, Geographical, and Geological distribution.

The nature and object of Classification.

In the *second part* of the Course will be considered:—

The modifications presented by the most important members of the sub-kingdoms *Protozoa* and *Cœlenterata*, with particular reference to the manner in which these simple forms of animal life exemplify the laws of Physiology, Morphology, and Distribution in space and in time, and to their agency in forming rock masses.

The structure, development, and physiology of *Bugula*, *Waldheimia*, *Phallusia*, *Buccinum*, *Helix*, *Cleodora*, *Sepia*, considered as typical examples of the chief classes of the sub-kingdom *Mollusca*.

The most important deviations from these types exhibited among the members of the classes and orders of the *Mollusca*, and the palæontological history of that sub-kingdom.

The structure and development of the *Lepidosiren*, the Dog-fish, the *Lepidosteus*, the Lamprey, and the *Amphioxus*, as typical examples of the chief orders of the Class *Pisces*.

The most important deviation from these types exhibited among the members of the orders of Fishes ; the palæontological history of Fishes.

The structure and development of the Frog and Newt as typical examples of the class *Amphibia*.

The chief modifications observable among the orders of *Amphibia*, and their palæontological history.

The structure and development of a Snake, a Lizard, a Tortoise, and a Crocodile, as typical examples of *Reptilia*.

The chief modifications observable among the orders of *Reptilia*, and their palæontological history.

The *third part* of the Course will be devoted to:—

The structure and development of *Hydratina*, *Aspidogaster*, *Tenia*, *Ascaris*, *Nemertes*, *Echinus*, *Polynoi*, *Scolopendra*, *Blatta*, *Scorpio*, considered as types of the sub-kingdom *Annulosa*.

The most important modifications of these types exhibited by the classes and orders of the *Annulosa* and their palæontological history.

The structure and development of the common Fowl, as a typical bird.

The modifications of structure observable in the orders of Birds, and their palæontological history.

The structure and development of the Dog, as a typical Mammal.

The extreme modifications of the Mammalian type observable in the *Monotremata* and *Marsupialia*, in the Porpoise, the Horse, the Bat, and in Man.

The characters of the orders, and their palæontological history.

The affinities of the *Mammalia* one with another, and the relations of Man to other Mammals.

Note books and examinations.—Students who propose to become candidates for Certificates of Proficiency, or for the Associateship of the Government School of Mines, are required to take careful notes of the Lectures on Natural History, and to subject their note books to occasional inspection ; they

are further particularly desired to attend the examinations which are held at stated intervals during the course.

Demonstrations.—As the relative age and sequence of geological formations are to a great extent determined by the evidence afforded by the Fossils they contain, and since, for this reason, a practical acquaintance with those organic remains, which characterize particular formations, is of the utmost importance to the geologist, the Lectures on Natural History are supplemented by a series of demonstrations of such characteristic fossils: these are given in the Museum, by Mr. Salter and Mr. Etheridge, to students who have already attended the Lectures on Natural History.

Mineralogy.

The lectures, which will be illustrated by specimens intended for close inspection, comprise :—

I. Crystallography, treated as an introduction to the science ; showing the leading classification of the crystalline forms, the laws by which their variations are determined, and their combinations, all considered with reference to the forms actually met with among crystallized substances.

II. The physical properties of minerals, viewed principally as aiding in the practical discrimination of the various species.

III. The elements of the chemistry of Mineralogy, with the use of the blow-pipe, and of such tests as are calculated to be serviceable to the miner, the geologist, the scientific traveller, or the general observer when in the field.

IV. The physiography or systematic description of minerals, including all the more important species and varieties, with particular reference to the mode and places of occurrence, both of those substances which bear a commercial value, and of those which derive their chief interest from geological and physical considerations.

Geology.

The first part of this course embraces the geological processes now in action on the surface and in the interior of the earth, an account of the more important mineral substances entering into the composition of rocks, together with an explanation

of geological terms, &c.: also the proofs of the origin of stratified rocks, resulting from degradation of the land, produced by the action of rain, rivers, frosts, glaciers, icebergs, accumulations of organic débris, &c. The nature of aqueous denudation, including the destruction of land by the sea, is explained, together with the general formation of continents and islands, mountain chains, table lands, and the different kinds of valleys. In connection with these subjects, the transport of matter by rivers, both mechanically and in solution, the formation of deltas, &c., and the general accumulation of great deposits of marine and freshwater strata are examined. The theory of the origin of salt lakes is considered; also, the detailed proofs that large areas of the earth's surface are now being elevated above, or depressed beneath the sea. The relations of coral reefs and of earthquake and volcanic phenomena to this branch of the subject are discussed. The theory of volcanoes and the analogies between existing volcanic phenomena and those of past geological periods are traced. The mode of occurrence of organic remains in the rocks, the fossilization of organic substances, and the consolidation of strata form other branches of this division of the course.

The second part includes the theory of the metamorphism of rocks with the origin of gneiss, granite, &c. Also a description of the whole series of geological formations, in stratigraphical order, beginning with the oldest known rocks and passing through the Palæozoic or Primary, Secondary, Tertiary, and more recent deposits. In this part of the course the manner of deposition of the various formations is described, the nature of their organic remains, the igneous rocks with which they are occasionally associated; and the origin and distribution of coal, the useful metals, rock-salt, the building stones, limestones, clays, &c. The laws by which questions connected with these and other important subjects are determinable are explained, as well as the connection of Geology with Physical Geography.

An account is also given of the use of instruments, of the mode of conducting geological surveys, and, under certain conditions, field excursions will be made for the purpose of affording practical illustrations of the subjects lectured upon.

Mining.

The purpose of the lectures on the Art of Mining is to impress on students the principles which should form the basis of the various operations of the miner, and to make them acquainted with examples of mining practice, as conducted under different circumstances in this and other countries.

The course will include the following heads:—

I. Detailed discussion of known facts connected with the deposits of the useful minerals; beds, strata, or seams; stream-works; lodes or mineral veins; flats; pipe-veins; stock-works; irregular masses; heaves or dislocations, and rules for searching for the dislocated and lost portion of a deposit.

II. Preliminary research, shoothing, trenching, costeaning.

III. Boring, as practised with different apparatus, with rods or rope, with various cutting and clearing implements.

IV. Tools employed in mining, in hard and in soft ground; in collieries and in metallic mines; blasting by various methods.

V. Principles of employment of mining labour.

VI. Modes of gaining access to, and lighting subterraneous cavities, including a comparison of the various safety lamps.

VII. Levels and shafts, or the main openings to underground works; driving and sinking.

VIII. Means of securing excavations by timbering, masonry, and tubbing; construction of dams.

IX. Exploitation, or the working away of veins and of strata.

X. Carriage or transport of minerals through the underground roads.

XI. Winding or raising in the shafts, with the machinery and apparatus required.

XII. Pumps and pumping engines.

XIII. Ventilation, its principles and practice; natural ventilation; artificial introduction of a moving power; distribution of air through the workings.

XIV. The mechanical preparation or dressing of ores.

In the final examination in this subject, regard will be had to the proficiency of the student in mechanical drawing.

Metallurgy.

The course of instruction in Metallurgy consists of lectures and laboratory practice.

The object of the lectures is the communication of such instruction as the student may be able to apply to the greatest practical advantage, when he may be subsequently engaged in conducting any metallurgical process.

In these lectures the processes of extracting metals from their ores are fully described; the chemical principles which they involve are explained, a detailed description is given of the furnaces and machinery employed, and as far as reliable information can be obtained the cost of production is stated. The illustrations consist of a very extensive series of specimens, diagrams, and models. Experimental demonstrations are occasionally introduced, but the time required for the satisfactory illustration by experiment of the chemical phenomena which occur in metallurgical process is generally so long as to make it impossible that in this respect the Lecturer of Metallurgy should follow the example of the Lecturer on Chemistry. However, in the Metallurgical Laboratory the students have the opportunity of conducting all necessary experimental investigations.

The lectures embrace the following subjects:—

- I. General considerations on the nature of metallurgical processes.
- II. On fuel. Estimation and comparison of the calorific power and intensity of various kinds of fuel.
- III. On the materials used in the construction of furnaces and metallurgical apparatus. Fire-clay, &c. Manufacture of fire-bricks, crucibles, &c.
- IV. Special metallurgical processes.
 - a. Copper-smelting; causes of the varieties of copper.
 - b. Extraction of zinc from its ores. Brass and preparation of calamine brass. Various alloys of copper and zinc used in the arts.
 - c. Lead-smelting. Refining and de-silverizing. Treatment of argentiferous copper.
 - d. Smelting of silver ores. Amalgamation by the Mexican and Freiberg processes; extraction by the Augustin and Ziervogel methods; other methods of extracting silver from its ores.
 - e. Treatment of gold ores. Methods of parting gold and silver on the large scale. Alloys of gold and silver for monetary and other purposes. Modes of assaying, with special reference to standards of common occurrence.

- f.* Extraction of mercury by various methods.
 - g.* Extraction of antimony from its ores. Alloys of antimony; type metal, &c.
 - h.* Extraction of bismuth from its ores.
 - i.* Extraction of nickel from its ores. Production of German silver.
 - k.* Treatment of cobalt ores. Manufacture of zaffre and cobalt colours.
 - l.* Preparation of the compounds of arsenic used in the arts, as arsenious acid, &c.
 - m.* Smelting of tin ores.
 - n.* Smelting and manufacture of iron, wrought iron, cast iron, and steel. A considerable part of the course is devoted to this subject.
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Metallurgical Laboratory.

This Laboratory is conducted by Mr. R. Smith, under the direction of Dr. Percy, and is devoted to practical instruction in Metallurgy. The nature of this instruction will be adapted to the special requirements of the student. It comprises,—

Assaying in all its branches, especially of the more important metals, such as iron, copper, lead, tin, alloys of silver and gold, &c. ; and the examination of ores and metallurgical products.

The ability of the student to make trustworthy assays is in every case thoroughly tested ; and no certificate of competency is given to a student who has not furnished satisfactory proof that he is able to obtain accurate results.

There are three sessions in the collegiate year, of three months each. The Laboratory hours are from 10 to 4 during November, December, January, and February ; and from 10 to 5 during the other months, with the exception of Saturdays, when the Laboratory is closed.

The charge for instruction in the Metallurgical Laboratory is *fifteen* pounds for three months ; *twelve* pounds for two months, and *seven* pounds for one month.

Applied Mechanics.

Principles of mechanism and mechanics, with their practical applications ; friction ; elasticity ; strength of materials, &c. ; regulators of velocity and dynamometers ; steam-engines, and other moving powers ; general construction, arrangement, and framing of machines, and forms of their individual parts.

Machine tools for working in wood or metal and various other machines for direct use.

In the final examination in this subject regard will be had to the proficiency of the student in mechanical drawing.

Mechanical Drawing

Instruction will be given in mechanical drawing, to enable the student to make correct drawings from apparatus and machinery, and to prepare the working drawings requisite for the guidance of the founder, smith, carpenter, and others in the construction of engines, engine-houses, machinery, and apparatus in general.

Proficiency in this subject will be recognized in awarding the prizes.

The examination papers for the past Session (1860-61) are appended, p. 33.

Lectures to Working Men.

Short courses of lectures at suitable periods of the year are given in the evening to Working Men. These courses are systematic, and arranged so as to illustrate, within the period of two years, the principal subjects taught at the Institution. Those for the ensuing Session include—

Metallurgy.

Chemistry.

Physics.

Evening Lectures.

The origin and intention of these lectures have already been explained. They will consist of four courses of ten lectures each, and will be of so strictly educational a character as to meet the wants of the training masters who desire to profit by the Science Minute of the Lords of the Committee of Council on Education.* The subjects and order of succession of the various courses will be nearly as follow :—

Physiology.		Physics.
Geology.		Chemistry.

* See "Directory (revised to March 1861), with Regulations for establishing and "conducting Science Schools and Classes," to be had of Chapman and Hall, 193, Piccadilly, price 6d.

EXAMINATION PAPERS
OF THE
STUDENTS
AT THE
GOVERNMENT SCHOOL OF MINES
For the Session of 1860-61.

EXAMINATION IN CHEMISTRY.

THEORETICAL EXAMINATIONS.

GENERAL INSTRUCTIONS.

Six hours are allowed for this paper.

Students are only permitted to attempt eight questions.

They may select the questions either from Series I., from Series II., or from both.

The value attached to the correct answer of each question in Series I. is 6, and those in Series II. is 9.

N.B.—A full and exact answer will in all cases gain more marks than an inexact or incomplete answer; though, in the former case, the question may be the more easy of the two, and have less marks attached to it.

SERIES I.

1. What is the difference between a chemical compound and a mechanical mixture?
2. Describe a chemical process by which hydrogen and one by which oxygen may be prepared from water.
3. What takes place when a current of chlorine is passed through a solution of potash?

4. State the chemical principles involved in the manufacture of phosphorus.
5. Describe some of the processes which are employed for separating the metals from their oxides and sulphides.
6. Give the theory of the action of mortars used for building purposes.
7. Describe the manufacture of aluminium.
8. Describe the method of estimating potassium, sodium, and ammonium when occurring together.
9. Give an outline of the process of determining carbon and hydrogen in elementary analysis.
10. Describe the method of preparing aniline.
11. State the preparation, the composition, the properties, and the principal decompositions of oxalic acid.
12. What are the conditions under which sugar undergoes butyric fermentation?

SERIES II.

1. A mineral, on analysis, was found to contain sodium, aluminium, and fluorine in the following proportions:—

Sodium	-	-	32.78
Aluminium	-	-	13.06
Fluorine	-	-	54.16

What is the formula of the compound?

The following equivalent to be used :

Sodium	-	=	23
Aluminium	-	=	13.75
Fluorine	-	=	19.

Give details of calculation.

2. Describe the action of sulphur on the alkaline carbonates at a high temperature, and the deportment of the resulting products under the influence of atmospheric air and acids.
3. State the chemical conditions involved in coal mine accidents, and in some of the precautions suggested with the view of averting them.
4. Describe the composition of the phosphates as an illustration of the monobasic, bibasic, and tribasic acids.
5. Give the composition of hydrochloric acid, of water, vapour, and of ammonia, by weight and volume, and state the specific gravities of these three compounds referred to hydrogen.
6. Give an outline of the manufacture of carbonate of sodium.
7. Describe the course of analysis followed in cases of poisoning by arsenic.

8. Describe one of the methods used in determining vapour-densities.

9. The analysis of an organic body, containing carbon, hydrogen, and nitrogen gave the following numbers :—

Substance burnt	-	-	-	-	0·2050 grains.
Carbonic acid (C O ₂) found	-	-	-	-	0·3017 „
Water found	-	-	-	-	0·2457 „

The density of the vapour of the substance referred to hydrogen as unity was found to be 29.

What are the composition and formula of the compound?

The following equivalents to be used :—

Hydrogen	-	-	-	-	1
Carbon	-	-	-	-	6
Nitrogen	-	-	-	-	14

Give details of calculation.

10. A given sample of malt contains 60 per cent. of starch, and 10 per cent. of glucosé (C₁₂, H₁₂, O₁₂). Assuming that the whole of the starch and glucose is converted into alcohol, how much malt, expressed in pounds avoirdupoise, ounces, and grains, would be necessary to produce one gallon of absolute alcohol at 15° 5 C (60° F)?

The specific gravity of alcohol, water being taken as unity = 0·7938 at 15° 5 C. (60° F).

The gallon of water at 15° 5 C (60° F) weighs 70,000 grains.

11. Describe the preparation of fulminate of mercury, and give the composition of this substance.

12. Give an outline of the process of saponification, and of the manufacture of soap.

The practical examination consists in the qualitative analysis of a mixture of several mineral acids and bases, of which the following are some examples :—

- | | |
|---------------------------|-------------------------|
| 1. Sesquioxide of Iron. | Sulphate of Magnesium. |
| Protochloride of Mercury. | Nitrate of Silver. |
| Nitrate of Barium. | 4. Sesquioxide of Iron. |
| Silica. | Nitrate of Barium. |
| Sulphate of Copper. | Sulphate of Copper. |
| | Chloride of Manganese. |
| 2. Sesquioxide of Iron. | Arsenious Acid. |
| Acetate of Lead. | 5. Sesquioxide of Iron. |
| Citric Acid. | Sulphate of Magnesium. |
| Chromate of Potassium. | Nitrate of Barium. |
| | Nitrate of Cobalt. |
| 3. Sesquioxide of Iron. | Nitrate of Silver. |
| Protochloride of Mercury. | |

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| 6. Sesquioxide of Iron.
Phosphate of Sodium.
Sulphate of Magnesium.
Arsenious Acid.
Nitrate of Cobalt. | 10. Potassium Alum.
Tartar Emetic.
Chromate of Potassium.
Ferrocyanide of Potassium.
Arsenious Acid. |
| 7. Potassium Alum.
Sulphate of Nickel.
Nitrate of Bismuth.
Ferrocyanide of Potassium. | 11. Potassium Alum.
Chloride of Manganese.
Phosphate of Sodium.
Arsenious Acid.
Sulphate of Zinc. |
| 8. Potassium Alum.
Nitrate of Cobalt.
Citric Acid.
Acetate of Lead.
Sesquioxide of Iron. | 12. Potassium Alum.
Sesquioxide of Iron.
Nitrate of Cobalt.
Sulphate of Nickel.
Chloride of Manganese. |
| 9. Potassium Alum.
Arsenious Acid.
Tartar Emetic.
Chloride of Tin and Ammonium. | |

A. W. HOFMANN.

EXAMINATION IN PHYSICS.

MORNING PAPERS.

[Three of these six.]

1. You are to convert a bar of iron into a permanent magnet by the action of the earth; how will you do it? In what respect does iron differ from steel as regards the acceptance and retention of magnetism?
2. How do you suppose the magnetic quality to be distributed in a magnet; describe some experiments which would justify the conclusion that every magnet is an assemblage of molecular magnets.
3. Can you devise an experiment to show clearly that a bar of iron in proximity with a magnet is itself a magnet, possessing like the latter two opposite poles and a neutral point between them?
4. State what you know regarding the origin and properties of the magnetic curves or lines of magnetic force.
5. State what you know regarding terrestrial magnetism, defining the terms, declination, inclination, magnetic equator, magnetic poles. State also what you know regarding the diurnal variation.
6. State what you know regarding the phenomena of diamagnetism.

[*Four of these eight.*]

1. Supposing you were required to demonstrate experimentally the law that like electricities repel, and that unlike electricities attract, each other, how would you do it?

2. You are furnished with a stick of sealing wax and a piece of flannel, and are required with these to charge a gold leaf electrometer with *positive* electricity; how will you do it?

3. Give a brief sketch of the theory of electric fluids, and illustrate the theory by applying it to a clearly described case of electric induction.

4. State what you know regarding the distribution of electricity on the surfaces of conductors, both spherical and elongated; give a scientific explanation of the action of pointed lightning conductors, and state the reason why lightning is so destructive to trees and buildings, while a metallic rod allows it to pass harmlessly away.

5. Describe and explain the electrophorus.

5. Describe and explain the Leyden jar.

7. Describe and explain the plate glass electric machine, and state precisely how the prime conductor is charged when the plate is caused to rotate between its cushions.

8. If you wished to fire a mine by the spark from a Leyden jar, what precautions would you take to secure the ignition of the gunpowder? State your reasons for the precautions which you would adopt.

AFTERNOON PAPER.

[*Three of these seven.*]

1. Give a drawing and a description which shall clearly illustrate the action of the hydraulic press.

2. Describe and explain the action of the great Geyser of Iceland.

3. Describe and explain the action of the common pump or common fire-engine.

4. How do you suppose sound to be propagated through the atmosphere? State its velocity in air, water, and some other substance; how is its velocity in air affected by temperature? Add, if you can, an explanation of the discrepancy between Newton's first calculation and the observed velocity of sound.

5. On what does the production of a musical sound depend? On what does the pitch of a note depend? Describe an instru-

ment which shall enable you to determine the number of vibrations per second due to a note of any given pitch.

6. What are nodes? What are ventral segments? How does a square plate divide when it gives its deepest note? How does a bell divide itself? What other modes of division are possible to a bell? Describe Chladni's mode of investigating the vibration of plates.

7. Give a full and clear explanation of the beats which are heard when two organ pipes of nearly the same length are sounded together.

[Four of these nine.]

1. How has it been strictly proved that the angle of incidence is equal to the angle of reflection? prove from this law that the image of an object in a plane mirror is as far behind as object is in front.

2. If a plane mirror from which a luminous beam is reflected be caused to rotate, the reflected ray will move with twice the angular velocity of the mirror; prove this.

3. In the case of a concave spherical mirror an object is placed first at an infinite distance, then at a place beyond the centre, then at the centre, then between centre and principal focus, then at the principal focus, and finally between the principal focus and surface of mirror; state the character and position of image formed in each of these cases.

4. What is meant by index of refraction? Under what circumstances does total reflection take place?

5. What is meant by the dispersion of light? Is it possible to neutralize the dispersion without at the same time neutralizing the refraction?

6. Describe an experiment which shall demonstrate the spherical aberration of a lens, and another that shall exhibit its chromatic aberration.

7. Give a sketch of the undulatory theory of light. What do you understand by plane polarized light? What is the relation between the reflected and the transmitted beam at the polarizing angle?

8. Describe an experiment which shall prove that the two beams into which a single beam is divided by passing through Iceland Spar are polarized at right angles to each other.

9. What is meant by the interference of light? Apply, as far as you can, the principal of interference to explain the colours of

thin films of uncrystallized bodies. In the case of a film of crystallized sulphate of lime, how is the retardation necessary to interference produced?

[Four of these eight.]

1. Describe the construction and graduation of an ordinary mercurial thermometer. 2d. Show how the degrees of F. D. Reaumur may be converted into one another.

2. What is meant by the co-efficient of expansion? You are required to describe the construction and principle of the gridiron pendulum.

3. A candle placed at the top of the open doorway of a room containing a large fire, has its flame blown outwards; if placed at the bottom the flame is blown inwards; account for these effects, and apply them to the explanation of trade winds.

4. What do you understand by vapour of 110? What by the condensation? What is meant by congelation of water? State all that occurs as regards heat when water passes from solid to liquid state, and from liquid to vaporous.

5. How is the conductivity of bodies for heat to be determined? If we wish to preserve pumps and fountains in frosty weather, we surround them by straw. If we wish to preserve ice from melting in summer we surround with straw and flannel; why? Explain the action of clothing in keeping the body warm.

6. Give a clear statement of the theory of dew, and explain how ice is sometimes formed when the temperature of the air a few feet above the earth's surface is several degrees above the freezing point of water.

7. Illustrate by some striking instances the different degrees in which heat is radiated and absorbed by different bodies; give also a few instances of the different transparency of bodies for radiant heat.

8. In investigating the diathermancy of gases and vapours, it was found necessary to stop the ends of the tube containing them by plates of rock salt; why would not glass answer? State, as far as you can remember, the action of gases and vapours upon radiant heat.

[4 of these 8.]

1. You are required to describe some simple means of generating a voltaic current; state the direction in which the current flows in the arrangement which you propose; and state also what you mean by the direction of the current.

2. You are required to determine the strength of a current ; first, by its action on a magnetic needle ; and, secondly, by its electro-chemical action. How would you proceed in the respective cases ?

3. A portion of the telegraph wire which unites London and Edinburgh, runs magnetically north and south. Supposing you had access to the wire while a message was passing, how would you ascertain whether the current passed from London to Edinburgh, or the reverse ?

4. Two plates of clean platinum are plunged into acidulated water, and a voltaic current is sent through the liquid from plate to plate ; how are the plates affected ? Apply your knowledge to explain the use of the nitric acid in Grove's battery.

5. State the relation which subsists between the length and thickness of a wire and the resistance which it offers to the passage of an electric current. Describe an experiment which shall illustrate the influence of temperature on the conductivity of a wire, and state the circumstances on which the heating of a wire by an electric current depends.

6. Sketch an apparatus by means of which you could decompose water by an electric current ; collect the gases and determine their relative quantities. Assuming a direction for the current, indicate the place at which the respective gases will appear.

7. Describe clearly how it is possible to make use of so bad a conductor as the earth as a portion of a telegraphic circuit.

8. Give an account of the origin and laws of induced currents ; first, showing how they may be produced by means of a permanent magnet, and afterwards by a voltaic battery. Apply your knowledge to explain some one form of the machines used for medical purposes.

JOHN TYNDALL.

EXAMINATIONS IN NATURAL HISTORY.

In consequence of an alteration in the arrangements of the School no Students presented themselves for this examination in the Session 1860-61.

Edward Forbes Medal and Prize.

MORNING.

1. State the distinctive characters of the class *Mammalia* and of its orders. Give examples of each of the latter, and state the range of the class in time.

2. Give the characters, affinities, and range in time, of the genus *Coccosteus*.

3. Give the character, affinities, and range in time, of the genus *Pterygotus*.

4. What are the characters of the class *Insecta* and of the orders of that class? Give examples of each of the latter, and state the range in time of the class.

AFTERNOON.

1. Describe the leading points in the structure of any dioecious *Gasteropod*. Compare its character with those of a dibranchiate *Cephalopod* and of a dimyary *Lamelli branch*.

2. Compare the vertebrate faunæ of the Pleistocene, Eocene, Oolitic, and Triassic epochs.

3. What is meant by Bathymetrical distribution? What organisms are capable of living at greater depths than five hundred fathoms?

4. What animals are truly oceanic, *i.e.*, habitually live at the surface of the sea, and, among these, which may contribute to the formation of sea-bottoms?

Give the class and order of the specimens numbered 1—8, and name any you know.

Questions for Examination in Palæontology.

[Conducted by Messrs. J. W. Salter and R. Etheridge.]

1. Give the characteristics of the earliest known organic remains, of *Oldhamia*, of *Fucoids*: with the first appearance known of Marine and Land Plants, Annelida, Crustacea, Mollusca, Fish.

2. Name the chief genera of *Graptolites* and *Cystidea*, and give their Geological range.

3. Mention any characteristics of the Starfish, Crinoids, Echinidæ, or Corals peculiar to the Palæozoic times, or to the Upper and Lower Palæozoic rocks respectively. Give examples.

4. Give the characteristics and geological place of

Paradoxides.

Ogygia.

Brachymetopus.

Didymograpsus.

Pseudocrinites.

Actinocrinus.

Platycrinus.

Favosites.

Michelinea.

Zaphrentis.

Lithostrotion.

Lonsdalia.

Petraia.

Camerocceras.

Clymenia.

Lepidodendron.

5. Mention some Brachiopod shells common to all Geological periods, and some peculiar to Silurian, Devonian, or Carboniferous rocks, with their characters.

6. Mention the genera of plants in the Coal, and give their characters. And name the specimens on the table.

1. <i>Neuropteris.</i>	4. <i>Temnocheilus.</i>
2. <i>Michelinea.</i>	5. <i>Lithostroton.</i>
3. <i>Calymene.</i>	

7. Describe the following genera:—*Pentacrinus*, *Apiocrinus*, *Bourgueticrinus*, *Marsupites*; give the strata they characterize and their range in time.

8. Describe the sections, and groups of the Belemnitidæ.

What species are peculiar to the Lias, Inferior Oolite, Oxford Clay, and Chalk?

9. To what division and families of the Echinidæ do the following genera belong?

<i>Cidaris.</i>	<i>Echinobrissus.</i>
<i>Hemicidaris.</i>	<i>Clypeus.</i>
<i>Salenia.</i>	<i>Micraster.</i>
<i>Diadema.</i>	

Give the characters of any of these; any marked peculiarities they possess, and their range in time.

10. What families of Corals are well illustrated in the Secondary and Tertiary epochs? Name those genera that characterize the Lias, Inferior Oolite or Cornbrash, Coral Rag, Lower Greensand, and London Clay, and give their more obvious characters.

11. Construct a table, showing the sections and groups of the Ammonites as defined by their external form, and draw lines to represent the range of the groups in time.

12. What genera of the Star Fishes characterize the Lias, Chalk and London Clay? Give the prominent characters of each genus named.

THOMAS H. HUXLEY.

EXAMINATION IN APPLIED MECHANICS.

20th April 1861.

1. Mention the two curves that are commonly employed for the shape of the teeth of wheels. Are they the only forms that can be used for the purpose?

2. Define a right-hand screw and a left-hand screw.

3. Explain the worm-wheel and worm.

4. How are right-handed and left-handed screws combined in the coupling link of railway carriage? Describe the link.

5. Describe the simple calculating machine for performing addition.

6. Explain the construction of a rope, and show how the fibres are made to retain their twist.

7. State the three laws of sliding friction.

8. Explain the varied motion of the punch in the machine used for punching boiler plates, and show how this motion is produced by a cam.

9. Show how the peculiar form of a steam engine, which is known as the oscillating engine, enables the cylinder to be brought nearer to the crank shaft.

10. Define the dead point in link work.

11. A flat endless belt connects two pulleys upon parallel shafts. If one of these pulleys be conical, the belt will always travel to the base of the cone. Explain this fact, and show how it is employed to give a form to the pulleys that will prevent the belt from slipping off.

12. How is a belt arranged so as to connect two pulleys, the direction of whose axes are neither parallel nor meeting?

13. Describe a common grinding machine moved by the foot, so as to show how it illustrates the general principles of mechanism.

14. Give a concise explanation of the different modes of applying the properties of steam, from which the various engines derive the respective names of atmospheric, high pressure, condensing and expansion engines.

ROBERT WILLIS.

EXAMINATION IN GEOLOGY.

1. How is it proved that the great volcanic areas of the world are generally areas of elevation?

2. Explain the theory of the formation of Coral reefs, and its connection with areas of depression and elevation.

3. What are the phenomena from which we infer the existence of central heat? and explain the chemical theory of volcanoes.

4. Describe two processes by which salt-lakes may be now forming, or have been produced in former times. The bearing of these on deposits of salt.

5. Explain the doctrines of super-position of strata, and of succession of life in time.

6. Explain the following terms :—Lamination, Bedding, Cleavage, Foliation, Metamorphism, Dip, Strike, and Fault.

7. In Scotland, for example, what are the mutual relations of Gneiss and other metamorphic rocks, and the granitic rocks with which they are associated ?

8. What is a Mineral Vein, and how does it differ from a bed, and from a dyke ?

9. Construct a column of the British stratified formations, placing the newest at the top, and the oldest at the bottom : draw vertical lines alongside, showing the range in time of any species, genus, order, or class of Fossils.

10. In the above column mark with a cross those formations that lie unconformably on the formation next below ; and between what great Marine formations are there complete breaks in the succession of marine life in time.

11. Explain the theory of the formation of the Coal of the Coalmeasures.

12. Draw a diagram showing the general stratigraphical relations of the Secondary to the Palaeozoic strata in England and Wales.

A. C. RAMSAY.

EXAMINATION IN MINING.

2d April 1861.

1. Enumerate in detail the varying conditions which may affect the value of a seam or bed of coal for mining purposes.

2. State the greatest depths to which in different countries, lodes or mineral veins have been followed by mining operations, and the changes in character observable in them from the surface downward.

3. Discuss the series of circumstances to be weighed in judging of the propriety of commencing operations in a lode.

Describe the arrangement of boreholes for proving the character of a series of conformable inclined strata.

5. Illustrate with drawings on a scale of 6 feet to 1 inch, the various methods of timbering shafts.

6. What are the modes of paying mining labour by piece or *tut-work* and by *tribute*, and their occasional advantages and disadvantages ?

7. Draw a section of a plunger lift as used in mines, and state its advantages as compared with other kinds of pumps.

8. Describe the working of coal by the long-wall system, 1st, with respect to the cutting or getting of the coal; 2ndly, with respect to the arrangement of the works.

9. Give a description of three of the best kinds of safety lamp; and state under what circumstances in a colliery Davy's lamp ceases to be secure, and what are the merits of the others hitherto introduced.

10. State, with due regard to velocities, areas, and volumes, the successive improvements which have been introduced into the general system of ventilation of the great collieries of Northern England.

11. What is the principle and construction of jiggling machines, and how may they be modified for the washing of coal?

WARINGTON W. SMYTH.

EXAMINATION IN MINERALOGY.

24th June 1861.

1. Enumerate the laws of crystallography which have reference to, 1st, the combinations of faces of different forms in crystals; 2dly, to the variable length of the principal axis.

2. Describe the chiefly important hemihedral forms of the cubical system of crystallization, indicating from what holohedral forms they are derived.

3. Illustrate by reference to some particular mineral the leading forms and combinations of the oblique system.

4. Give examples among the non-metallic minerals of substances in which the colour is characteristic, and of others in which colour is no criterion.

5. Describe fully the more important minerals from which iron is manufactured.

6. State what minerals commonly occur with the above, and what substances which contain a large per-centage of iron are nevertheless unfit for iron making.

7. Name 12 specimens placed on the table, stating by what characteristics the species are recognizable.

8. Give an account of the physical characters of the three species formed by oxide of Titanium.

9. What are the physical and chemical characters of some four silicate minerals frequently found to occur in metamorphic rocks?

10. Describe mineralogically the gems termed sapphire, spinel, amethyst, opal, and zircon, and name their chief localities.

11. What are the characteristics of Wolfram, and what the uses to which it has been applied?

12. How may you readily distinguish from one another by inspection the minerals Copper-glance, Galena, Antimonite, Molybdenite and Graphite?

13. State the character, by formulæ or description, of six crystal models, and refer each to the mineral species which it may represent.

WARINGTON W. SMYTH.

EXAMINATION IN METALLURGY.

June 8th, 1861.

1. What are the maximum theoretical temperatures produced by the perfect combustion of carbon and hydrogen respectively, as well by atmospheric air as by pure oxygen?

2. Describe the principles on which the various kinds of coke ovens are constructed.

3. Of what material are Dinas fire-bricks made, and in what parts of furnaces is it desirable to employ them?

4. Describe succinctly the method of copper smelting as practised at Swansea, and the theory of the process.

5. Describe the apparatus and furnace employed in the extraction of zinc by the Belgian method.

6. Explain the reduction of Galena in smelting in the reverberatory furnace.

7. How may lead and copper be desilverized?

8. By what methods are gold and silver separated on the large scale?

9. Explain the principles on which Ziervogel's method of extracting silver is founded.

10. What are the chief properties and uses of nickel?

11. Describe the refining of tin, and state the nature and qualitative composition of the products obtained.

12. State the so-called foreign ingredients which may be expected to occur in various kinds of pig iron.

13. On what principles are the various methods of converting pig iron into bar iron founded?

14. Describe succinctly the various modes of preparing steel, and especially the principles on which they are founded.

15. Name the specimens upon the Table No. 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively. They were Clay, Iron Ore, Earthy Calamine, Blue Metal, Lead Slag from Ore earth, Nickel, Red Hæmatite, Magnetic iron ore, Speigleisen, and Cleveland iron ore.)

JOHN PERCY.

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LIST OF GEOLOGICAL MAPS AND SECTIONS OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM,

PUBLISHED BY MESSRS. LONGMAN & Co. FOR HER MAJESTY'S STATIONERY OFFICE.

THE Maps are those of the Ordnance Survey, geologically coloured by the Geological Survey of Great Britain and Ireland, under the Superintendence of Sir RODERICK IMPEY MURCHISON, F.R.S., Director-General. The various Formations are traced and coloured in all their Subdivisions.

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- 42 SW. SW. of Brecknock, part of North Glamorgan and East Carmarthen.
- 42 SE. NE. of Glamorgan and Monmouth Coalfield.
- 43 NW. The Old Red Sandstone and part of the Silurian Strata of Woolhope.
- 43 NE. Silurian District of Woolhope, with the Malvern Country as far North as the Wych.
- 43 SW. The West of Dean Forest Coalfield.
- 43 SE. The greater part of Deau Forest Coalfield.
- *44 Cheltenham, East Gloucestershire. 6s.
- *45 SW. Part of Oxfordshire (Woodstock).
- 45 NW. Banbury.
- *45 NW. Part of Warwickshire—Coventry.
- 53 SW. Southam. Part of Warwickshire.
- 53 SE. Northampton.
- *53 NE. Part of Northamptonshire and Warwickshire.
- 54 NW. Part of Worcestershire.
- 54 NE. Part of Warwickshire.
- *54 SW. Part of Worcestershire.
- 54 SE. Part of Warwickshire.
- 55 NE. Part of Shropshire and Worcestershire.
- 55 NW. Part of Hereford, Worcester, and Shropshire.
- 55 SW. Part of Hereford.
- 55 SE. Part of Hereford and Worcester.
- 56 NW. Part of Brecon, Cardigan, Radnor, and Montgomery.
- 56 NE. Part of Radnor, Montgomery and Shropshire.
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- 60 NW. Part of Montgomery and Merioneth.
- 60 NE. Part of Montgomery and Shropshire.
- 60 SW. Part of Cardigan, Montgomery, and Shropshire.
- 60 SE. Part of Montgomery, Radnor, and Shropshire.
- 61 NW. Part of Shropshire.
- 61 NE. Part of Shropshire and Staffordshire.
- 61 SW. Part of Shropshire.
- 61 SE. Part of Shropshire.
- *62 NE. Lichfield, part of Staffordshire.
- *62 SE. Birmingham, part of Warwickshire.
- *62 SW. Part of Staffordshire, including the Coalfield.
- *62 NW. Part of Staffordshire, including the Coalfield.
- *63 NW. Ashby-de-la-Zouch, part of Leicestershire.
- *63 NE. Leicester.
- *63 SW. Hinckley, part of Leicestershire and Warwickshire.
- *63 SE. Part of Leicester, Warwick, and Northamptonshire.
- 71 NE. Nottingham.
- 71 NW. Nottingham, part of Derbyshire.
- 71 SW. Derby.
- 71 SE. Part of Nottinghamshire.
- 72 NW. Hanley. Part of Staffordshire.
- 72 NE. Part of North Staffordshire and of SW. Derbyshire.
- 72 SW. Central Part of Staffordshire.
- *72 SE. Part of Staffordshire and SW. Derbyshire.
- *73 NW. Part of Cheshire.
- *73 SW. Part of Shropshire.
- 73 SE. Part of Shropshire and Staffordshire.
- 73 NE. Crewe.
- 74 NW. Part of Denbigh, Merioneth, and Caernarvon.
- 74 NE. Part of Denbigh, Flint, Shropshire, and Merioneth.
- 74 SW. Part of Montgomery, Denbigh, and Merioneth.
- 74 SE. Part of Shropshire, Montgomery, and Denbigh.
- 75 NW. Part of Caernarvon.
- 75 NE. Part of Caernarvon, Merioneth, and Denbigh.
- 75 SW. Part of Caernarvon.
- 75 SE. Part of Merioneth.
- 76 N. Part of Caernarvon.
- 76 S. Part of Caernarvon.
- 77 N. Part of Holyhead Island.
- 77 NW. N. part of Anglesea, and part of Holyhead Island.
- 78 NE. E. corner of Anglesea.
- 78 WS. S. of Holyhead Island and of Anglesea, with part of Caernarvonshire.
- 78 SE. Part of Anglesea on Menai Straits, NE. of Caernarvonshire, and W. of Denbighshire.
- 79 NW. Part of Flint, Denbigh, and Caernarvon.
- 79 NE. Part of Flint, Cheshire, and Lancashire.
- 79 SW. Part of Flint, Caernarvon, and Denbighshire.
- 79 SE. Part of Cheshire, Flint, and Denbigh.
- 80 NE. Nearly ready.
- 80 SE. Northwich.
- 80 SW. Chester, part of Cheshire.
- *80 NW. Part of Cheshire and Lancashire.
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